Interpretation of 1980/81 Surveillance Data for the International Waters of the Saint John River Basin

A Report of the International Technical Advisory Subcommittee on Water Quality in the Saint John River Basin

February, 1983

INTERPRETATION OF 1980/81 SURVEILLANCE DATA

FOR THE

INTERNATIONAL WATERS OF THE SAINT JOHN RIVER BASIN

A REPORT OF THE
INTERNATIONAL TECHNICAL ADVISORY SUBCOMMITTEE
ON WATER QUALITY IN THE
SAINT JOHN RIVER

June, 1982

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Mr. David Egar
Mr. Lester A. Sutton, P.E.
Co-Chairmen
Canada-United States Committee on Water
Quality in the Saint John River

Gentlemen:

The International Technical Advisory Subcommittee on Water Quality in the Saint John River Basin has pleasure in submitting to you its report for the monitoring year 1980-1981. The reporting period includes January 1980, to capture some data missing from our last monitoring report, to September 1981. The data reported come from three routine monitoring programs and two short-term surveys.

Although a few analytical problems remain, water in the portion of the basin covered by the Subcommittee's activities is generally capable of sustaining the fishable/swimmable uses. In particular, dissolved oxygen levels in the main stem below Edmunston showed improvement throughout the summer of 1981, meeting the objectives for the first time in recent years. On the other hand, the upper Saint Francis River, and perhaps a 3.0 km stretch of the Saint John River below its confluence with the Madawaska River, do not meet the objectives for fecal coliforms.

Several recommendations have been made on the future course of the monitoring programs operated by the Maine Department of Environmental Protection, Environment Canada, and the United States Geological Survey. A recommendation to institute control action has been made in respect of the St. Francis River. Your consideration of these matters is requested.

Yours very truly,

R. Wilson, Chairman
International Technical Advisory Subcommittee
on Water Quality in the Saint John River

MEMBERS OF THE SUBCOMMITTEE

Robert C.H. Wilson (Chairman)
Environment Canada

Canada	U.S.A.
Dr. Paul E. Belliveau Environment Canada	Mr. James A. Barresi Northern Maine Regional Planning Commission
Mr. Jerry S. Choate Environment New Brunswick	Mr. Fred LaVallee* Maine Department of Environmental Protection
Mr. Donald C. Riley Fisheries and Oceans Canada	Mr. Ray E. Thompson Environmental Protection Agency
Ms. Denyse Gouin Environnement Quebec	Mr. Derrill J. Cowing U.S. Geological Survey Department of the Interior

* Mr. LaVallee was replaced by Mr. Gary Westerman in February, 1982.

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1. SUMMARY AND RECOMMENDATIONS

1.1 An increased level of monitoring, recommended in 1980, was achieved during the 1980/81 sampling season for all water quality characteristics except mercury concentrations. More sensitive detection limits, also as recommended, were achieved for most, excepting aluminum and mercury for U.S. data.

1.2 Dissolved phosphate levels appear to be meeting the safe objective, although this is based upon U.S. data only. Canadian stations, which were monitored for total phosphate in 1980/81, should be monitored for dissolved phosphate in future.

1.3 Most main stem and tributary stations met both safe and acute objectives for As, Cu, Pb and Zn. Some high mean values for Cu and Pb did occur, which after partial correction, met the objectives. Values could be corrected only partially because data on hardness, pH, T°, alkalinity and humic acids did not accompany the individual measurements of these metals. Lead levels at Lincoln School did not meet the safe objective, even after partial correction, but this was based on too few samples (3) to be definitive. On an annual basis, Zn levels were within the objectives, but the U.S. data indicate that a "slug" of water with high Zn levels may have passed downriver in late winter/early spring of 1981. It is recommended that there be an increased level of monitoring for zinc in the main stem.

1.4 Based on Canadian data, all main stem stations met the safe objective for aluminum. All three tributaries studied had sample means that exceeded the safe objective. Due to the more elevated pH and aluminum levels on the Aroostook and Presquile/Prestile,

short intensive surveys are recommended for these two rivers only, with continued monitoring recommended for the Meduxnekeag. More U.S. data, of improved sensitivity, is required for the American segments of all three tributaries.

1.5 All main stem and tributary stations met the safe and acute objectives for dissolved oxygen and % oxygen saturation, but there was indication of oxygen depletion downstream of Green River, even during a high water year. Continuous monitoring for DO between Edmunston and Grand Falls is recommended.

1.6 Temperatures along the main stem were lower than in the previous monitoring year, and within the safe objective, only once exceeding the acute level. All tributaries met the safe (summer) objective except the Aroostook at Caribou. Stations at Caribou and at Tinker exceeded the acute level. A short intensive survey to determine the trophic state of the Aroostook, to include temperature, DO and dissolved phosphate measurements, is recommended. The survey should also determine whether summer temperatures can be lowered by changing operations at the Caribou and Tinker dams, or in another way.

1.7 It is recommended that NAQUADAT should submit temperature data averaged by season rather than a yearly average.

1.8 All main stem and tributary stations met the safe objective for pH. The upper acute limit was exceeded on the Presquile. The present level of monitoring of the Presquile should continue, and a survey should be made to determine the reason for the high pH.

1.9 All stations met the safe and acute objectives for un-ionized ammonia and suspended solids.

1.10 Fecal coliform log means on the main stem from the Madawaska River near Edmunston to 3.0 km below St. Basile and at St. Leonard/Van Buren appear to have exceeded the swimmer's objective. Individual samples also exceeded the recommended level. All other stations met the swimmer's objective except for the St. Francis River from Lake Pohenegamook to Lac Beau. It is recommended that fecal coliform sampling be repeated on the main stem in 1982/83 and that biochemical confirmation tests for fecal coliforms be carried out on samples that exceed the 200/100 ml level.

1.11 It is recommended that control measures be instituted to reduce the fecal coliform levels in the upper St. Francis River.

1.12 Sampling for heavy metals should be concurrent with sampling for pH, temperature, humic acids, hardness and alkalinity, and future data should be reported in such a manner that individual metal levels can be associated with the corresponding values for these parameters.

1.13 It is again recommended that the analytical sensitivity for mercury be improved for U.S. data. The mercury analyses reported by NASQUAN and STORET cannot safely be interpreted.

1.14 Fish kills affecting both salmonids and coarse fish species occurred on the Saint John River and the Aroostook River in the summer months of 1981. The kills were observed 2-3 miles downstream of St. Leonard, approximately 5 miles downstream of Mactaquac, and at the Tobique fishway in early July and August and at the Tinker Dam headpond during the EPS monitoring program in June-August.

Causative agents that were proposed included: parasite infestations, bacterial/viral infections, gas bubble disease,

pesticide residues, low dissolved oxygen concentrations, and a spill of turbine oil at Beechwood. However, no cause could be identified, mainly due to the advanced stage of decomposition of most specimens when collected.

The 1980/81 monitoring data presented in this report neither point the way to new theories nor lend support to any of those previously considered, except for high temperatures being at least partially responsible for the Aroostook kills.

The Canadian Department of Fisheries and Oceans will be closely monitoring the situation during the coming summer for similar occurrences. Increased monitoring and/or short, intensive surveys will have to be considered for the future if the kills occur again and continue to thwart all efforts to find the cause.

2. INTRODUCTION

A fishable (salmonids/aquatic invertebrates)-swimmable goal for the international portion of the Saint John River Basin has been established and water quality objectives developed by the International Technical Advisory Subcommittee (ITAS)[1]. Implementation of a recommended monitoring program[2] necessitates comparison of the resulting data with the objectives. Monitoring data from water year

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[1] Review and update of water quality objectives for the international waters of the Saint John River Basin. ITAS, September 1980.

[2] Water quality data analysis and sampling program for the international waters of the Saint John River Basin. ITAS, January 1979.

1979/80 suggested that eutrophication may have been occurring in the international portion of the Saint John River as evidenced by high phosphate and low oxygen levels. The major problem identified for heavy metals was with the actual data: too few samples and inadequate detection limits made proper assessment of water quality impossible[3].

These problems were addressed in water year 1980/81, in addition to the needs of the regular surveillance program. This report summarizes the results of several monitoring programs undertaken in Canada and the United States, and identifies potential water quality problems in terms of non-compliance with the established "safe", "acute" and "swimmer's" objectives.

Graphs of the results can be found at the end of this report, from page 36 on.

3. 1980/81 MONITORING PROGRAMS

The data under discussion in this report were obtained from five different monitoring programs, two of which were included in the previous data interpretation report, the other three being "new" this year. The data sources which have been represented previously are the Canadian NAQUADAT and the State of Maine's STORET systems.

Beginning in 1980/81, the USGS has provided monthly physical/chemical data for several stations in the Saint John River basin, with continuous temperature data, presented as daily maxima/minima, for two of these stations (Van Buren and the Aroostook at Caribou) through its NASQUAN system.

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[3] Interpretation of 1979/80 surveillance data for the international waters of the Saint John River Basin. ITAS, October 1980.

In addition, four short surveys were undertaken during the summer of 1981. One was an intensive physical/chemical/bacteriological survey carried out by EPS, Atlantic Region, on the main stem of the Saint John River and the Aroostook, Presquile and Meduxnekeag tributaries. Samples for temperature, DO and fecal coliforms were collected for each site at three points across the rivers (near each bank and mid-way). Samples for pH and aluminum were collected from mid-river only. A short pH-fecal coliform survey of the St. Francis River was then carried out by EPS in August. The third survey was a bacteriological/chemical survey of the St. Francis River conducted by the Water Quality Branch of the Quebec Region of ECS (Environmental Conservation Service of Canada) in July, 1981, and a fourth short survey and analytical crosscheck for fecal coliforms was conducted in August, 1981, by the Atlantic Region WQB.

The above data sources are represented throughout this report by the following code letters:

A - WQB, Moncton (NAQUADAT)
B - DEP (STORET)
C - EPS, Atlantic
D - USGS (NASQUAN in part)
E - WQB, Quebec.

For the purpose of the discussion and the graphs in this report, tributary stations in the vicinity of the main stem proper, e.g., those on Green River, Grand River and the Madawaska, have been included in those sections designated as pertaining to the "Main Stem".

Water qualities that were monitored and are discussed herein are those that are relevant to the "fishable-swimmable" objectives for the Saint John River basin. They are comprised of:

- temperature (A, B, C, D)
- dissolved oxygen/% oxygen saturation (A, B, C, D)

- pH (A, B, C, D, E)
- dissolved phosphate (B, D)
- un-ionized ammonia (A, B, D)
- aluminum (A, B, C)
- arsenic (A, D)
- copper (A, B, D)
- lead (A, B, D)
- mercury (A, B, D)
- zinc (A, B, D)
- suspended solids (D, E)
- fecal coliforms [and fecal streptococci*] (A, B, C, D*, E*).

The time frames for the data from the various sources were generally as follows:

WQB, Moncton: January 1980-September 1981, monthly to bimonthly sampling

DEP: April 1980-July 1981, monthly sampling

USGS: October 1980-September 1981, monthly to tri-monthly, with some continuous monitoring

EPS, Atlantic: June-August 1981, daily for shorter periods

WQB, Quebec: July 1981, one to three samples from each station.

The stations sampled under the various programs are illustrated in Figures 1-3 and described in Table 1. Data summary tables are available upon request. STORET data summaries were submitted with single values, arithmetic means per calendar year, and medians per sampling year; NAQUADAT submitted only the ranges and arithmetic means per sampling year; EPS, Atlantic submitted single values and both geometric and arithmetic means;

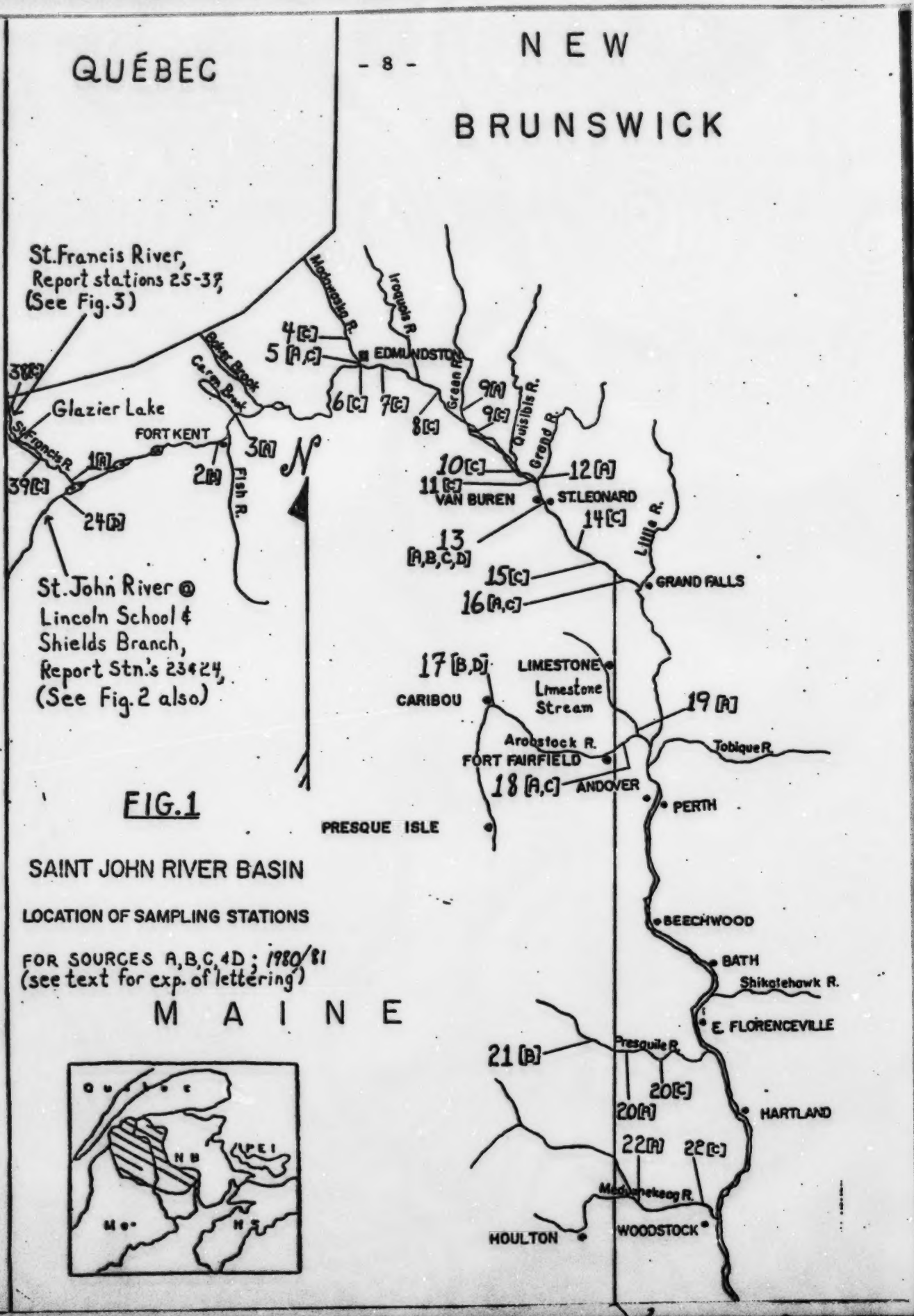

FIG.1

SAINT JOHN RIVER BASIN

LOCATION OF SAMPLING STATIONS

FOR SOURCES A,B,C,4D ; 1980/81
(see text for exp. of lettering)

MAINE

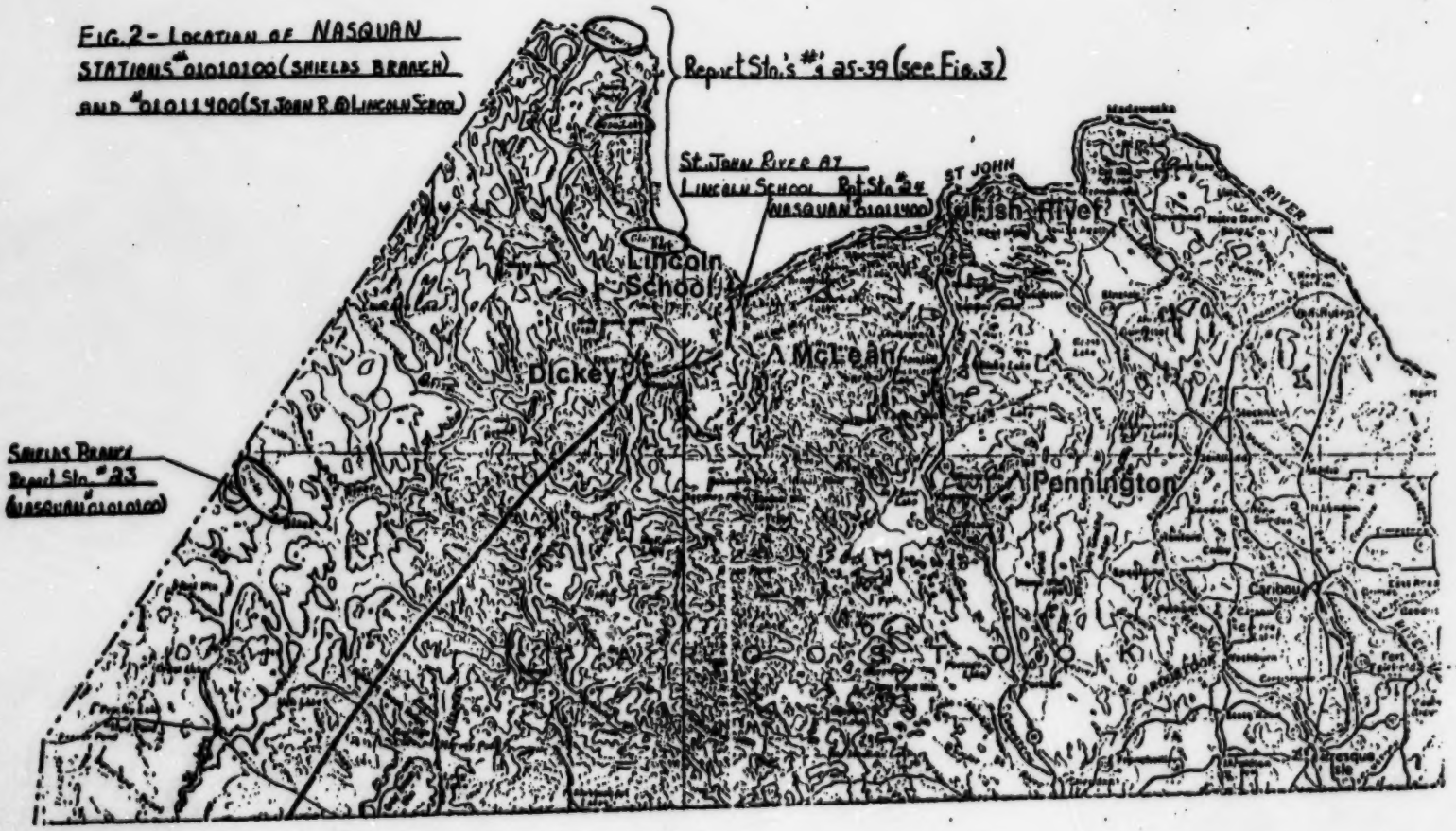
Report Sta.'s #'s as-39 (see Fig. 3)
St. John River at Lincoln School Rpt Sta #24 (Nasqaun #01011400)
St John River
Fish River
Lincoln School
Dickey
A McLean
Pennington
Shields Branch Rpt Sta #23 (Nasquan #01010100)

FIG. 2 - LOCATION OF NASQUAN STATIONS #01010100 (SHIELDS BRANCH) AND #01011400 (ST. JOHN R. @ LINCOLN SCHOOL)

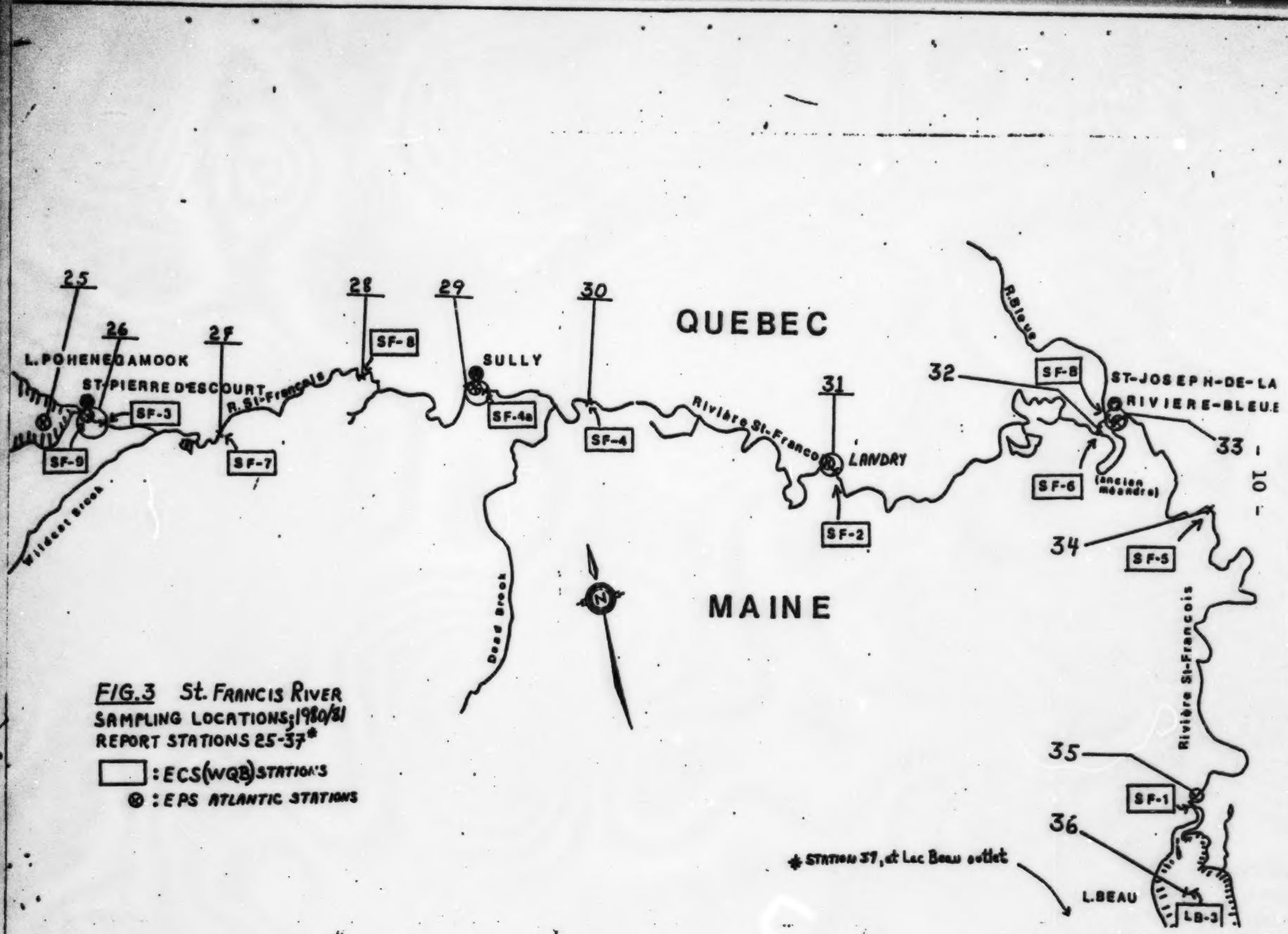

FIG.3 St. FRANCIS RIVER
SAMPLING LOCATIONS: 1980/81
REPORT STATIONS 25-37*

□ : ECS (WQB) STATIONS

⊗ : EPS ATLANTIC STATIONS

TABLE 1 - SAINT JOHN RIVER BASIN MONITORING STATIONS, 1980/81

m = Center of River
l = Left Bank When Looking Downstream
r = Right Bank
c = Canadian Side
a = U.S. Side

Report Station #	Sources & Station #'s	Station Descriptions
1	NAQUADAT 00NB01AD0013	St. Francis River at picnic site
2	STORET J560C	Saint John River, from center of Route 1 bridge between Fort Kent and Clair
3	NAQUADAT 00NB01AD0017	Saint John River at Caron Brook
4	EPS #12 l, m, r	Madawaska River at Fournier Bridge (below Fraser Brook)
5	NAQUADAT 00NB01AD0016	Madawaska River at Edmundston below Fraser outfall
	EPS #11 l, m, r	Madawaska at CN crossing in Edmundston
6	EPS #1 c, m, a	Edmundston-Madawaska international bridge
7	EPS #2 c, m, a	Saint John River below Madawaska Island
8	EPS #3 c, m, a	Saint John River below St. Basile
9	NAQUADAT 00NB01AF0021	Green River at WSC gauge
	EPS #4 c, m, a	Saint John River 0.5 km below Green River

.../Cont'd

TABLE 1 (Continued) - SAINT JOHN RIVER BASIN MONITORING STATIONS, 1980/81

m = Center of River
l = Left Bank When Looking Downstream
r = Right Bank
c = Canadian Side
a = U.S. Side

Report Station #	Sources & Station #'s	Station Descriptions
10	EPS #5 c, m, a	Saint John River at Ste. Anne de Madawaska
11	EPS #6 c, m, a	Saint John River above les Trois Isles
12	NAQUADAT 00NB01AF0013	Grand River at TCH bridge
13	NAQUADAT 00NB01AF0002	Saint John River off international bridge at St. Leonard
	EPS #7 c, m, a	Saint John River at St. Leonard-Van Buren bridge
	STORET J100C	Saint John River from bridge between Van Buren, Maine and St. Leonard, to indicate water quality of Saint John River before leaving the Maine boundary
	USGS (NASQUAN) 01015000	Saint John River at Van Buren, Maine
14	EPS #8 c, m, a	Saint John River below Six Mile Island
15	EPS #9 c, m, a	Saint John River at Hamlin, Maine

.../Cont'd

TABLE 1 (Continued) -- SAINT JOHN RIVER BASIN MONITORING STATIONS, 1980/81

m = Center of River
l = Left Bank When Looking Downstream
r = Right Bank
c = Canadian Side
a = U.S. Side

Report Station #	Sources & Station #'s	Station Descriptions
16	NAQUADAT 01NB01AF0005	Saint John River above dam at Grand Falls
	EPS #10 c, m, a	Saint John River, 0.5 km above Grand Falls dam
17	STORET JAR149L	Aroostook River, from the Caribou dam, left bank
	USGS (NASQUAN) #01017100	Aroostook River at Caribou, Maine
18	NAQUADAT 01NB01AG0001	Aroostook River at forebay of Tinker dam
	EPS #15 l, m, r	Aroostook River at Tinker
19	NAQUADAT 00NB01AG0003	Limestone Stream at Four Falls
20	NAQUADAT 00NB01AJ0012	Big Presque Isle Stream at Canada/ U.S. border
	EPS #14 l, m, r	Big Presquile at Highway 2
21	STORET JPR174C	Prestile Stream, from center of Route 10 bridge in Easton

.../Cont'd

TABLE 1 (Continued) - SAINT JOHN RIVER BASIN MONITORING STATIONS, 1980/81

m = Center of River
l = Left Bank When Looking Downstream
r = Right Bank
c = Canadian Side
a = U.S. Side

Report Station #	Sources & Station #'s	Station Descriptions
22	NAQUADAT 00NB01AJ0029	Meduxnekeag River at Belleville
	EPS #13 l, m, r	Meduxnekeag at Wooodstock
23	USGS #01010100	Sheilds Branch, Big Black River near Seven Islands, Maine
24	USGS #01011400	Saint John River at Lincoln School, Maine
25	EPS #16	Lake Pohenegamook, near exit into St. Francis River
26	EPS #17	St. Francis River at Pohenegamook
	ECS (WQB) Quebec Region, SF-9	St. Francis River, just below St. Pierre d'Escourt, below Lake Pohenegamook
	ECS (WQB) Quebec Region, SF-3	St. Francis River just below SF-9
27	ECS (WQB) Quebec Region, SF-7	St. Francis River, below entry of Wildcat Brook
28	ECS (WQB) Quebec Region, SF-8	St. Francis River, approximately mid-way between SF-7 and Sully

.../Cont'd

TABLE 1 (Continued) - SAINT JOHN RIVER BASIN MONITORING STATIONS, 1980/81

m = Center of River
l = Left Bank When Looking Downstream
r = Right Bank
c = Canadian Side
a = U.S. Side

Report Station #	Sources & Station #'s	Station Descriptions
29	EPS #18	St. Francis River at Sully
	ECS (WQB) Quebec Region, SF-4a	Just below Sully in the St. Francis River
30	ECS (WQB) Quebec Region, SF-4	below Sully and entry of Dead Brook, in the St. Francis River
31	EPS #24	St. Francis River at Landry
	ECS (WQB) Quebec Region, SF-2	St. Francis River at Landry
32	ECS (WQB) Quebec Region, SF-6	St. Francis River at beginning of the old meander, above St. Joseph-de-la-Riviere-Bleue
33	EPS #19	St. Francis River at Riviere-Bleue
	ECS (WQB) Quebec Region, SF-8	at St. Joseph-de-la-Riviere-Bleue on the Riviere-Bleue
34	ECS (WQB) Quebec Region, SF-5	St. Francis River below St. Joseph-de-la Riviere-Bleue
35	EPS #20A	Beau Lake (head)
	ECS (WQB) Quebec Region, SF-1	head of Lac Beau

.../Cont'd

TABLE 1 (Continued) - SAINT JOHN RIVER BASIN MONITORING STATIONS, 1980/81

m = Center of River
l = Left Bank When Looking Downstream
r = Right Bank
c = Canadian Side
a = U.S. Side

Report Station #	Sources & Station #'s	Station Descriptions
36	ECS (WQB) Quebec Region, LB-3	center of Lac Beau
37	EPS #20B	Beau Lake (outlet)
38	EPS #23A	Glazier Lake (head)
39	EPS #23B	Glazier Lake (outlet)

USGS/NASQUAN submitted single values and generally did not summarize data; WQB, Quebec sometimes gave the mean of three separate samples from three sampling dates and sometimes the median of three means generated by triplicate fecal coliform analyses.

4. RESULTS, DISCUSSIONS AND CONCLUSIONS

As in the previous surveillance report[3], the data have been compared to the safe objectives and acute limits for the protection of fish and other aquatic life, with the exception of fecal coliform data which has only a "protection for swimmers" objective. In all cases where fishable objectives are met, the swimmers objective would also be met, except for mercury and un-ionized ammonia for which the swimmer's objective lies in the range between the safe and acute fishable objectives.

The safe objective represents a long-term water quality management goal. Annually or seasonally averaged data are compared to it. Individual measurements are compared to the acute limit, which is viewed as an alert level, in order to "red flag" potential problems. By request of the Canada-U.S. Committee, and for ease of interpretation, summary data are represented in the body of the report as graphs rather than tables. Each graph includes the suite of stations sampled for the particular water quality characteristic under discussion; horizontal lines representing the safe and acute objective levels for that characteristic; and vertical bars representing the range of the data obtained by each data source at each station. The relative positions of arithmetic ( ) and geometric ( ) means within these range bars are also shown. In calculating geometric means, values below detection were arbitrarily given values of 90% of the relevant detection limit. In calculating the arithmetic means and medians, STORET designated these values as equal to the detection limit; the USGS/NASQUAN data were treated similarly for this report.

4.1 Temperature (Figure 4)

4.1.1 Main Stem (Junction with the St. Francis, to Grand Falls)

Mean temperatures along the main stem always met the safe objective, although out of 491 measurements identifiable as summer data (June-September), 169 or 34% were greater than 20°C. Only one of these exceeded the acute objective (25°C), this at the STORET Fort Kent-Clair station, in July 1981. Temperature maxima that approached but did not meet the acute level, that is, those in between 24-25°C, were occasionally recorded at:

- NAQUADAT stations at Caron Brook and above the Grand Falls dam;

- EPS stations at the Edmundston-Madawaska international bridge, below Green River, above les Trois Isles and at St. Leonard-Van Buren;

- the USGS continuous monitoring station at St. Leonard-Van Buren during July and August, although the single monthly data point for this same station from the NASQUAN water chemistry program recorded only 21.0°C for July. Monthly arithmetic means during the 1981 summer for the continuously monitored site ranged from 14.5°C in September to 21°C in July.

There is a trend in the June-August 1981 EPS data for water temperatures along the U.S. side to exceed those along the Canadian side by 0.5-2.0°C. EPS summer data had geometric means ranging from 16.4°C to 19.6°C.

The NAQUADAT data gave yearly rather than seasonal averages, making comparison with the seasonal objectives impossible for this data set.

The desired winter maximum of 8°C was never exceeded according to the winter data.

Main stem water temperatures had moderated somewhat in 1980/81 from the levels reported for the previous water year. The main stem is considered to be meeting the safe objective for temperature.

4.1.2 Tributaries

4.1.2.1 The Aroostook

Temperatures recorded in the Aroostook varied from 0.0-26.0°C. The highest temperatures were recorded from the continuously monitored USGS site at the Caribou Dam, and at the NAQUADAT station at Tinker Dam. Temperature maxima ≥25°C were recorded on six occasions in July and four in August by the USGS. On two dates in July, temperature minima were above the acute level. During the summer months at Caribou, the "desirable" level was exceeded in July and almost met in August using both daily maxima and minima for the computations (22.5 and 19.5°C, respectively). The desirable level was exceeded on 54 dates out of the 122 dates monitored, or 44%.

The USGS continuous monitoring station at Caribou was closed at the end of September, 1981. STORET data ended in June 1980 and supplied a single value of 17.0°C for that month (June 3). This compares well with the USGS maximum for the same date, but in 1981, which was also 17.0°C. In view of the high temperatures that can be reached at the site during summer, however, with the acute level being approached or exceeded for several days at a time during July and August, it is recommended that the level of effort of temperature monitoring at Caribou be increased.

At the Canadian sites at Tinker Dam, a maximum of 26.0°C was also recorded by NAQUADAT, while EPS maxima for the three cross-river sites were

each 23.5°C. The EPS geometric mean for the site during the summer was 18.4°C. The NAQUADAT station on Limestone Stream at Four Falls had a maximum recorded temperature of 24°C.

All winter temperatures met the winter objective.

The Aroostook may not be meeting the safe nor acute temperature objectives during summer if the high temperatures are due to man's activities. This means that, in the vicinity of the monitoring sites at least, it is unsuitable habitat for salmonids.

4.1.2.2 The Presquile/Prestile

Temperature means were within the safe range during summer, but at least once equalled the acute level in the NAQUADAT data. Summer geometric means from EPS were in the 14.3-17.4°C range, below that for the Aroostook and the main stem. The Prestile (STORET) Easton station recorded a temperature of 20.5°C, well below the temperature minimum and maximum of 23.5 and 24.5°C recorded by the USGS at Caribou on the Aroostook for the same date (July 9).

No winter temperature violations were recorded.

The Presquile/Prestile appears to have been within the objectives in 1980/81.

4.1.2.3 The Meduxnekeag

Summer temperature maxima barely exceeded the desirable level and were well below the acute level. The EPS geometric means for the three cross-river stations were 18.5°C. No winter violations were recorded.

4.1.2.4 Shields Branch, and the Saint John River at Lincoln School

The limited data available for the period May-September 1981 (five readings) for each of these areas indicate that average temperatures (12.0 and 12.7°C, respectively) and maxima (15.0 and 17.0°C, respectively) were well below those for the sites monitored further downstream along the main stem and also well within the safe objective.

4.2 Dissolved Oxygen/% Oxygen Saturation (Figures 5 and 6)

4.2.1 Main Stem

No sample exceeded the "acute" level, that is, no single sample had <5 mg/L dissolved oxygen. All means and even most individual samples were within the "80% saturation or greater" safe range. The data indicate some oxygen depletion as the water approaches the Grand Falls headpond, evidenced by the increase in frequency of individual samples falling below 80% saturation, although these stations still met the objective on a seasonal/annual basis. Upstream of Green River, geometric and arithmetic means were always above 90% saturation. Downstream means were rarely >90%, and usually 83-88%. Individual values for dissolved oxygen <6.5 mg/L occurred frequently from Trois Isles to Grand Falls. The lowest level, 5.8 mg/L, was measured from the Canadian side at Hamlin, Maine. These levels generally gave saturation values of 68-75%. However, the situation is an improvement over 1979/80 when reported minimum levels at St. Leonard and Grand Falls were 57 and 59%, means were 72.5 and 74% respectively, and the DO concentrations were below the acute level at St. Leonard. In view of the tendency towards oxygen depletion in the vicinity of the Grand Falls headpond, however, even during a high water flow year, and considering the benefits for data interpretation from using continuous monitoring data (see Temperature Section, for example), it is concluded that continuous monitoring for dissolved oxygen in the stretch of river between Edmundston and Grand Falls would be advantageous for water quality management of the main stem.

No trend to higher % saturation levels along either bank or mid-channel was evident in the data.

4.2.2 Tributaries

4.2.2.1 The Aroostook

Means for % saturation (safe) and individual measurements for dissolved oxygen (acute) met the objectives. Saturation minima of 72 and 63% were reported by NASQUAN and NAQUADAT from Caribou. The lowest reported level on the Aroostook was 6.8 mg/L, from Tinker Dam (NAQUADAT).

4.2.2.2 The Presquile/Prestile

The Presquile waters met safe and acute objectives based on data means and individual samples. Percent saturation values ranged from 87.7-105.8% and dissolved oxygen values from 8.3-13.7 mg/L.

4.2.2.3 Shields Branch and the Saint John River at Lincoln School

Both of these water systems were well within the objectives when sampled (May-September 1981). Dissolved oxygen and % saturation minima were within the objectives (9.3 mg/L; 91 and 96%). The means were among the highest obtained for the Saint John River basin in 1980/81.

4.3 pH (Figure 7)

4.3.1 Main Stem

All sample means fell well within the safe objective, and ranged from 6.9 to 7.5. Individual sample minima ranged from 6.25 to 7.1; maxima from 7.1 to 8.8; all meeting the acute objectives.

4.3.2 Tributaries

Means for the Aroostook, Presquile, Meduxnekeag and the St. Francis fell within the range of the safe objective. All individual samples met the acute objectives and, except for the Presquile, the safe objective as well. For the Presquile, both NAQUADAT and EPS data gave relatively high geometric means of 8.2. The EPS maximum (8.8) for the border station approached the upper safe limit of 9.0 and the NAQUADAT maximum (9.1) for the same station exceeded it on one occasion out of nine. STORET data for the Prestile at Easton reported a maximum pH of ">8.40". It is concluded that relatively elevated levels of pH occurred in the Presquile/Prestile stream in 1980/81, as appeared to be the case in 1979/80, although on an annual basis the data met the safe objective. An increased level of monitoring for pH is recommended for the Presquile.

4.4 Dissolved Phosphate (Figure 8)

The data available on dissolved phosphate levels for the main stem and tributaries are limited, partly because total phosphorous rather than total dissolved phosphate was measured in the NAQUADAT and EPS samples. The lowest level established for data comparison, 0.015 mg/L, was based on State of Maine experience relating dissolved phosphate levels to algal blooms.

4.4.1 Main Stem

Using the available data set (STORET and NASQUAN), it appears that in the summer of 1981, main stem waters met the safe objective for phosphate (0.015 mg/L), although the single sample from the St. Leonard/Van Buren STORET site exceeded it in April of 1980 (0.017 mg/L). In 1981, single samples from the Fort Kent and St. Leonard/Van Buren sites ranged from 0.001-0.013 mg/L giving station means of <0.010, 0.0025 and 0.007

However, the number of samples was too few to properly assess the water quality of the main stem with regard to phosphate. NASQUAN data for phytoplankton at Van Buren during 1981 indicated a peak of 1100 cells/ml, below the level considered indicative of eutrophication.

4.4.2 Tributaries

Data for 1980/81 exists only for the Aroostook and Presquile.

4.4.2.1 The Aroostook

The Aroostook River at Caribou was generally high in dissolved phosphate, exceeding the safe objective according to NASQUAN data. The single value for phosphate from STORET was for April 1980, and was elevated (0.011 mg/L) but within the safe objective. The NASQUAN monthly sampling of phytoplankton during the summer of 1981 showed a maximum of 8000 cells/ml on the July sampling date, a level indicative of eutrophication. Based on these data, a short intensive survey is warranted to determine the trophic state of the river. This was also implicated by the temperature and DO data.

4.4.2.2 Presquile/Prestile

The Presquile/Prestile at Easton, Maine, exceeded the safe limit in one of the two samples reported for 1980/81 (July 1981), with a value of 0.026 mg/L. It is concluded that monitoring should be increased on this river for dissolved phosphate.

4.5 Un-ionized Ammonia

Means for all stations along the main stem and for all tributary stations were well within the safe objective. Individual samples were not only well below swimable and acute levels, but were also below the safe

level. Highest maxima, approaching 0.001 mg/L un-ionized ammonia, were calculated for Aroostook and Presquile stations, and for one sample out of seven from Fort Kent (August 1980 - 0.0014 mg/L). However, even these maxima were below the safe objective. A graph of these data was considered unnecessary.

4.6 Aluminum (Figure 9)

The safe objective set for the Saint John River basin, 0.1 mg/L Al as total extractable, applies only to water with a pH of 7.0 or greater. This is because aluminum is amphoteric, the toxicities of its cationic forms which would exist at low pH being unknown at the time of the objective review in 1980, and the pH of the Saint John River generally being >6.0. Recent work has concentrated on aluminum toxicity in waters more acid (pH 4.0 to 5.2) than is relevant for the Saint John River. Aluminum solubility is at a minimum at pH 5.5, increasing to either side of this value[4] and is regulated by some form of aluminum trihydroxide solid which is minimally soluble at pH 5.6-6.0[5]. It is concluded that the safe objective of 0.1 mg/L determined for pH $\geq$7.0 for the Saint John River, should also provide at least equal protection for pH's between 6 and 7. Data for 1980/81 were therefore interpreted by applying the safe and acute objectives to all aluminum values obtained because accompanying pH measurements were always >6.0.

Although 8 out of 11 geometric means exceeded the safe objective in 1979/80, conclusions regarding aluminum levels on the Saint John River

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4 U.S.-Canada Working Group I Impact Assessment of Trans-Boundary Air Pollution. October 1981. Chapter. 3.

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5 Driscoll, C.T. 1980. Ph.D. Thesis, Cornell University, U.S.A.

could not be reached at that time because the limit of detection used in the monitoring, undertaken only by NAQUADAT, equalled the safe objective. It was therefore decided to include aluminum in the 1980/81 programs and to refine analytical techniques. The NAQUADAT method for 1980 had a detection limit of 0.02 mg/L and 0.01 mg/L in 1981. EPS data for 1981 also had a detection limit of 0.01 mg/L. STORET included aluminum in its 1980/81 data for the first time, but that system's detection limit apparently only equalled the safe objective (0.1 mg/L).

When one compares the Canadian 1979/80 data with the more sensitively derived 1980/81 Canadian data, and also the Canadian and U.S. 1980/81 data for aluminum, it becomes apparent (Table 2) that the data sets with the lower detection limits have lower geometric and arithmetic means as well.

4.6.1 Main Stem

Based on the Canadian data for 1980/81, all sites along the main stem met the safe objective except for the NAQUADAT station on the Grand River at the Trans-Canada Highway, which had a geometric mean of 0.13 mg/L. At this station, individual samples exceeded the safe objective four times out of seven, but never exeeded the acute limit (1.0 mg/L). Stations downstream of Grand Falls met the safe objective.

Based on the U.S. data, however, both the Fort Kent and Van Buren station means exceeded the safe limit, although no single value exceeded the acute limit.

It is conluded that continued monitoring rather than a short intensive survey is warranted at this time. The U.S. samples should be analyzed using a methodology with detection limits comparable to those for Canadian data. If the discrepancy between the data sets persists, a short intensive survey would then be justifiable.

TABLE 2 - COMPARISON OF ALUMINUM DATA, 1979-1981, FOR THE SAINT JOHN RIVER MAIN STEM

Source	NAQUADAT	NAQUADAT	EPS	STORET		
(Detection Limit)	1979/80 (0.1 mg/L)	1980/81 (0.01, 0.02 mg/L)	Summer 1981 (0.01 mg/L)	1980 (0.1 mg/L)	1981 (0.1 mg/L)	June & July only, 1981; Single Values
Geometric Means						
Range	.10-.22	.02-.13	.03-.10	--	--	--
Average	.143	.077	.067	--	--	--
Arithmetic Means						
Range	--	--	.05-.10	.16-.17	.17-.29	.12-.28
Average	--	--	.08	.165	.23	.21

4.6.2 Tributaries

4.6.2.1 The Aroostook

Only Canadian data were available for 1980/81 on the Aroostook. Geometric means for the Tinker Dam station approached the safe objective in one case (0.09 mg/L) and exceeded it in the other (0.21 mg/L). No single sample exceeded the acute objective.

For the NAQUADAT station on Limestone Stream at Four Falls, the geometric means (0.24 mg/L) exceeded the safe objective and in at least one case out of seven, an individual sample equalled the acute level of 1.0 mg/L.

On the basis of having exceeded the safe objective, a short intensive survey appears warranted for the Aroostook River and Limestone Stream. This survey should aim at determining whether the aluminum being measured is labile.

4.6.2.2 The Presquile/Prestile

The geometric means from the Canadian data were 0.05 and 0.14 mg/L for average pH values of 8.2 and 8.7, respectively. In view of the high pH values at which aluminum solubility is greatly enhanced, and the safe objective being exceeded in one of these two data sets, a short intensive survey appears warranted. STORET data for 1980 and 1981 from Easton had means in excess of the safe objective (0.113 and 0.180 mg/L, respectively).

4.6.2.3 The Meduxnekeag

Geometric means were 0.08 mg/L and 0.11 mg/L from the NAQUADAT and EPS data sets, respectively, which slightly exceeds the safe objective

in one of two cases. Ranges of pH values for the same data sets were 6.1-8.1 and 7.8-8.2. Continued monitoring rather than a short intensive survey appears warranted at this time for the Meduxnekeag.

4.7 Arsenic (Total, Extractable) (Figure 10)

Means and individual samples were well within the objectives at all stations. The level of monitoring appears to be adequate.

4.8 Copper (Total, Extractable) (Figure 11)

The number of samples per station per monitoring program ranged from 6-10, which was an increase over the number collected in the last monitoring year. Also, the detection limit for STORET data was lowered from that for 1979/80, as had been recommended.

All NAQUADAT stations along the main stem and tributaries were found, on the basis of geometric means, to be within the safe objective of 0.005 mg/L. All individual samples from these stations were below the acute level of 0.02 mg/L.

U.S. data indicated that station arithmetic means at Fort Kent (STORET, in 1980 only) and St. Leonard/Van Buren (STORET 1980 and NASQUAN 1980/81) exceeded the safe objectives, before correction for hardness, pH, T°, and humic acids (as directed by the objectives review of 1980[1]). This correction could not be completed because only the NASQUAN system included data on water hardness, and no information on humic acids was available. Based upon the water hardness data alone (42.5 mg/L as carbonate on average, 41 mg/L as carbonate on the day of the highest copper reading), the 48-hr LC50 for copper is approximately 0.0925 mg/L[1]. Multiplying by the recommended safety factor of 0.1 results in a partially corrected "safe" value of 0.00925 mg/L. The Fort Kent station meets this level for the 1980 and 1981 data sets, and the Van Buren station for its

1980/81 NASQUAN and STORET 1981 data only. The remaining non-complying STORET data from Van Buren spans the time period April-November 1980, and results from a single anomalously high value of 1.9 mg/L for November. STORET data for Van Buren from January to July 1981, based on seven samples, meets the safe objective even before correction.

It is concluded that the waters of the Saint John River basin for water year 1980/81 met the safe and acute objectives for copper, that the value of 1.9 mg/L may have resulted from contamination during sampling/analysis, and that monitoring for copper should be continued.

4.9 Lead (Total, Extractable) (Figure 12)

Sampling effort as determined by the number of analyses (per program)/station had increased over last year - 6.1 samples/station for 1980/81 compared with 2.6 samples/station in 1979/80. Also, detection limits apparently were lowered for U.S. data as had been recommended, from 0.02 mg/L to 0.001 mg/L for STORET data. However, several maxima in the STORET 80/81 data were reported as "<0.03 mg/L" which has made the determination of meeting the objective (0.005 mg/L) impossible for that data set. NASQUAN data also had a detection limit of 0.001 mg/L in 1980/81.

Based on the Canadian data, all stations on the main stem and the Aroostook, Presquile and Meduxnekeag tributaries met the safe objective. Based on the four NASQUAN samples, the Van Buren station slightly exceeded it, 0.006 vs. 0.005 mg/L, as did the Lincoln School station. At Lincoln School the average lead concentration was 0.010 mg/L, but this was based on only three samples.

The Van Buren site had a hardness range of 39-50 mg/L as $CaCO_3$, averaging 42.5 mg/L with a pH range and average of 6.9-7.3 and 7.1, respectively. At this hardness, the 48-hr LC50 for rainbow trout for

lead is approximately 1.1 mg/L; at 20 mg/L hardness it becomes approximately 0.9 mg/L[1]. Using the EPA application factor of 0.01 results in a corrected "safe" objective of 0.011 mg/L which the Van Buren station meets.

There are no accompanying hardness data for the Lincoln School site, but the pH range and average were 6.7-7.0 and 6.8, respectively. Using the average hardness of 20 mg/L for the river, as stated in the 1980 objective review[1], and the EPA correction factor, the 48-hr LC50 becomes 0.009 mg/L, which the Lincoln School site slightly exceeds. However, this is based on only three samples and cannot be regarded as a proper assessment of the water quality with respect to lead at that station.

It is concluded that a short intensive study is not warranted, but that the present level of effort of monitoring for lead be at least maintained in 1981/82, and that pH, hardness and alkalinity data accompany that for lead.

4.10 Mercury (Total, Extractable) (Figure 13)

The level of monitoring, averaging 3.3 samples (per program)/ station, was not an improvement over that for 1979/80, which averaged 4.4 samples (per program)/station. In addition, both U.S. data sets had detection limits which exceeded the safe objective: 0.1 µg/L for NASQUAN, 0.2 µg/L for STORET, 0.064 µg/L for the safe objective. NAQUADAT was able to drop its detection limit from 0.05 µg/L to 0.02 µg/L by 1981. These differences in sensitivity may be responsible for differences in average values of the data sets as was indicated for aluminum. For example, one can look at the results for the St. Leonard/Van Buren station which was sampled during three monitoring programs. The Canadian data (NAQUADAT) ranged from <0.02-<0.05, with a hypothesized geometric mean of <0.02 µg/L. The U.S. data ranged from 0.1 to <0.3 with reported means of 0.15 and 0.25 µg/L, both of which exceed the safe objective.

Similar discrepancies occur between Canadian and U.S. data for the Aroostook and the Presquile/Prestile. Based on Canadian data, all stations (main stem, Aroostook, Presquile, and Meduxnekeag) met the safe objective. Based on the U.S. data, no station met the safe objective except possibly the Lincoln School site where the average of the two samples collected was less than detection (at 0.1 µg/L). Based on all the available data, no individual sample exceeded the swimmer's (2.0 µg/L) nor the acute fishable (3.2 µg/L) objectives.

It is again concluded that analytical sensitivities for mercury should be improved for U.S. data. It is also concluded that the data are insufficient to indicate whether a mercury problem exists in the Saint John River basin, and that the level of effort of monitoring needs to be increased.

4.11 Zinc (Figure 14)

The level of effort of sampling was increased over that of 1979/80 from an average of 2.4 samples to 8 samples (per program) per station. The STORET detection limit apparently was lowered from 0.002 mg/L to 0.001 mg/L, while NAQUADAT's remained at the 1979/80 level of 0.002 mg/L. NASQUAN reported no data <0.010 mg/L so that this is taken to be at or near their detection limit.

The Canadian data indicated that all stations met the safe (0.03 mg/L) objective. The U.S. stations also met the safe objective on an annual basis except for the NASQUAN Van Buren site, due to a high value of 0.07 mg/L reported for March 1981. This value was also the highest single value obtained in 1980/81 and approaches but does not exceed the acute limit. However, the mean value of the data set in question is below the lowest incipient lethal level of zinc to juvenile Atlantic salmon, i.e., below 0.15 mg/L (Zitko and Carson, 1976[1]).

The other high individual values for zinc were obtained by STORET at Fort Kent and Van Buren in February, 1981 (0.053 and 0.021 mg/L, respectively).

It is therefore concluded that elevated levels of zinc above the safe objective occurred in the Saint John River in the late winter/early spring of 1981, and that because these levels were not distinguishable on an annual basis, the present level of monitoring may not be adequate for zinc. Water hardness data again are required but lacking.

4.12 Suspended Solids

Based on the data available for suspended sediments from a very limited number of stations on the main stem, Aroostook and the St. Francis, the Saint John River waters appear to have met the safe objective for suspended solids. The July 1981 value for the NASQUAN Van Buren station approached the safe objective (25 mg/L) with a reading of 20 mg/L, but all other values were 1-8 mg/L at that station. Other values for all stations ranged between <1 and 9 mg/L, including the St. Francis, which is far below the acute level of 100 mg/L.

The level of monitoring associated with the NASQUAN program would appear to provide an adequate level of monitoring for this water quality characteristic. It is concluded that this characteristic should continue to be monitored at least during periods of high runoff.

4.13 Fecal Coliforms (Figure 15)

Fecal coliforms were sampled on the main stem and most tributaries in 1980/81 because they had not been monitored since 1977. However, the St. Francis River was surveyed because of U.S. concern about untreated sewage entering the river at Pohenegamook. Prior to 1975, it was considered to be non-polluted by domestic effluents and suitable for

fishing and swimming. Since that time a sewage collection system has been installed, but the intended treatment plant has yet to be built. The collected raw sewage is discharged directly into the St. Francis River at a point just below Lake Pohenegamook. The only industry in the area is comprised of one or two saw mills and there is some agricultural activity on the Quebec side of the river. The St. Francis was sampled for sewage contamination for the first time in 1980.

Before presenting the data, it should be noted that approximately 48% of the fecal coliform analyses done for the EPS program were in cold storage for 24-48 hours before analysis rather than the recommended six hours or less. The values obtained should not be strictly interpreted therefore, because coliform die-off and population increases of false-positive producing bacteria (such as Klebsiella spp.) may have affected the results. In addition, biochemical confirmation of fecal coliform tests were not performed for the data submitted by any of the sources.

Geometric means calculated using only samples analyzed on the same day of collection were generally lower, and the variation between counts was reduced if the other analyses were omitted, but ignoring the results for the samples analyzed 24-48 hours after collection does not affect the following conclusions.

4.13.1 Main Stem

The data indicate that the Madawaska River near Edmundston and the Saint John River on the Canadian side from Edmundston to a point 2.9 km below St. Basile did not meet the swimmer's "safe" objective. In this same area, individual samples exceeding 1000/100 ml were frequent. Based on the geometric means submitted by EPS, the remainder of the Saint John River, the Aroostook, the Presquile and the Meduxnekeag were within the safe objective, but individual samples exceeded the 1000/100 ml acute objective along the main stem in 8% of the samples.

It is concluded that the main stem from the Madawaska near Edmundston to 3.0 km below St. Basile probably did not meet the swimming objective, but this cannot be definitely stated in view of the unduly long storage time that elapsed between sampling and analysis for many of the samples, and the lack of confirmation that observed high levels were indeed caused by fecal coliforms and not other organisms found naturally in the environment and frequently in high numbers in pulp mill effluents.

4.13.2 St. Francis River

Both data sets indicated very high levels of fecal coliforms in the St. Francis River between St. Pierre-d'Escourt and Lac Beau, although, perhaps significantly, WQB Quebec's fecal coliform and fecal streptococci counts were both zero just below the Lake Pohenegamook outlet to the St. Francis (above the sewage source), but EPS fecal coliform geometric mean for Lake Pohenegamook near the St. Francis was 33/100 ml with an arithmetic mean of 126/100 ml.

Fecal coliform and streptoccus counts indicated that sewage contamination of the St. Francis occurs just below Lake Pohenegamook, at Sully (Report Station #29), and at the Riviere Bleue from St. Joseph-de-la-Riviere-Bleue. Counts lessened beyond this point but, based on three samples instead of the recommended five, were still beyond the swimmer's objective at the entrance to Lac Beau. With dilution in Beau Lake, fecal colforms met the objectives at the Beau Lake outlet and further downstream in Glazier Lake.

It is therefore concluded that the St. Francis River from Lake Pohenegamook to Lac Beau did not meet the swimmer's objective in 1980/81.

FIG. 4

ST. JOHN RIVER BASIN
WATER TEMPERATURE; 1980/81

A : geometric mean
● : arithmetic mean
○ : summer data (June-Sept.)
□ : winter data (Dec.-March)

B1 : April-Dec. '80
B2 : Jan-July '81
B3 : April-June '80

D1: USGS continuous monitoring data
D2: monthly NASQUAN data, Oct '80-Sept '81
D3: monthly NASQUAN data, May-Sept. '81

(for other letter codes, see text)

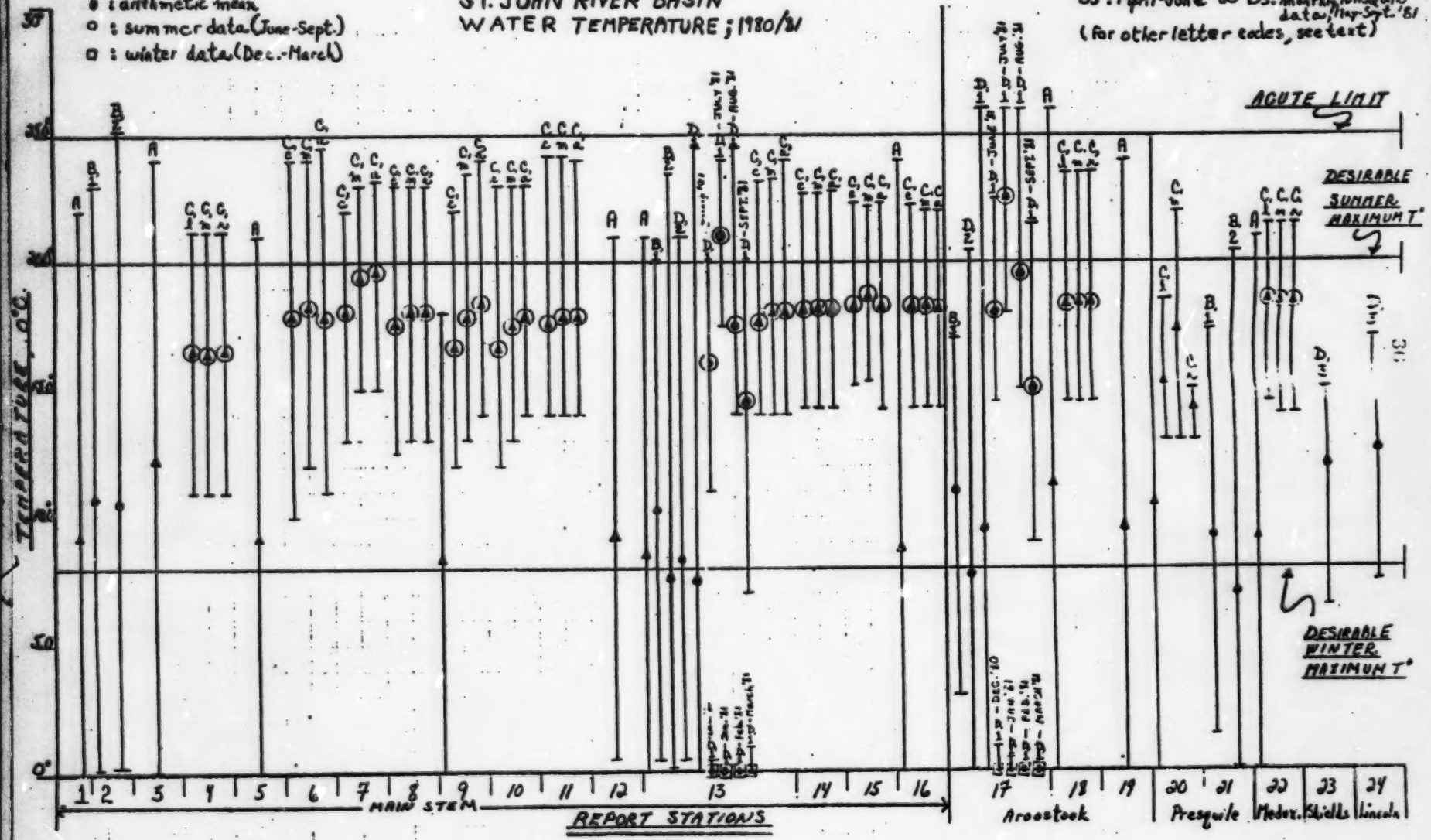
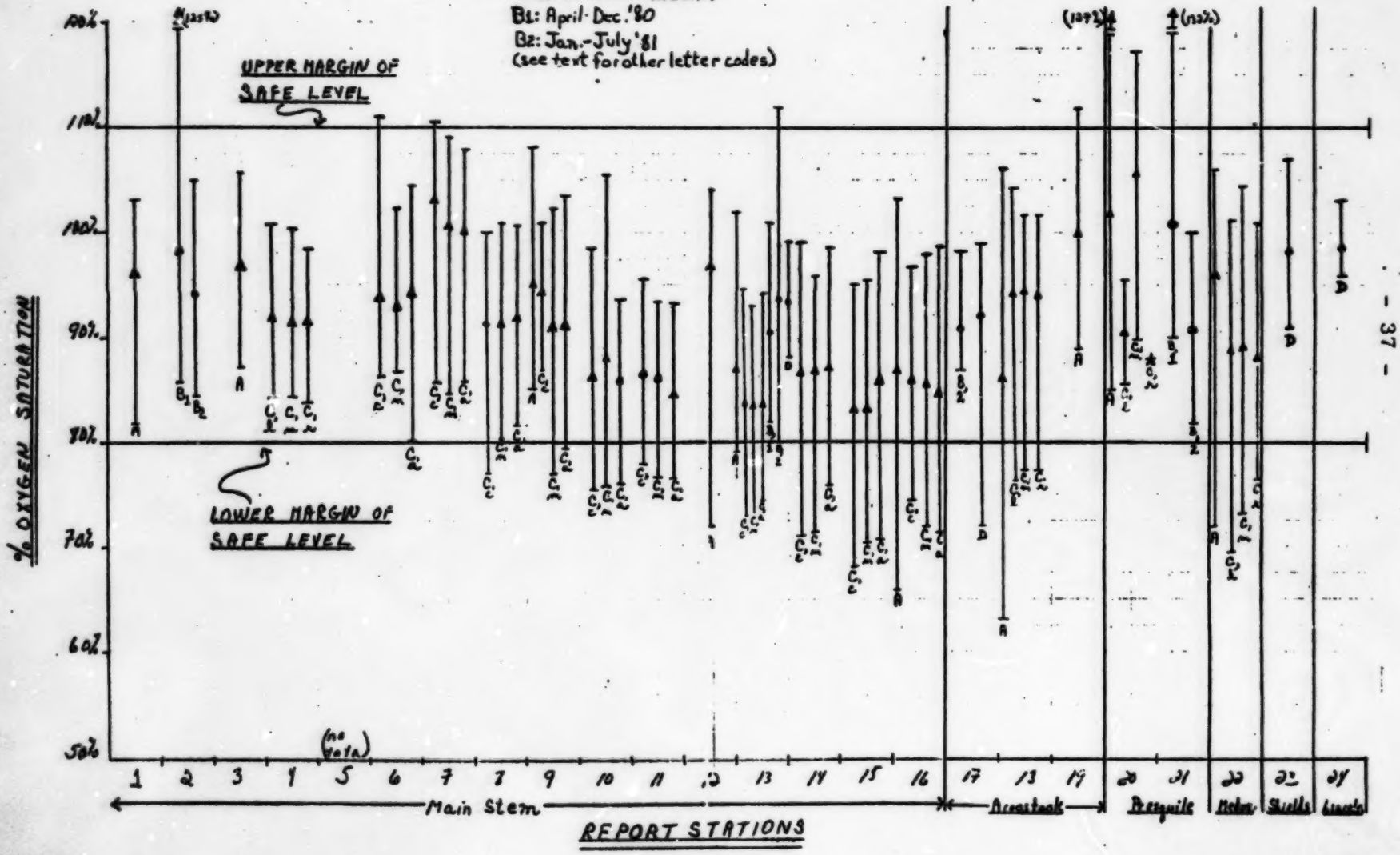
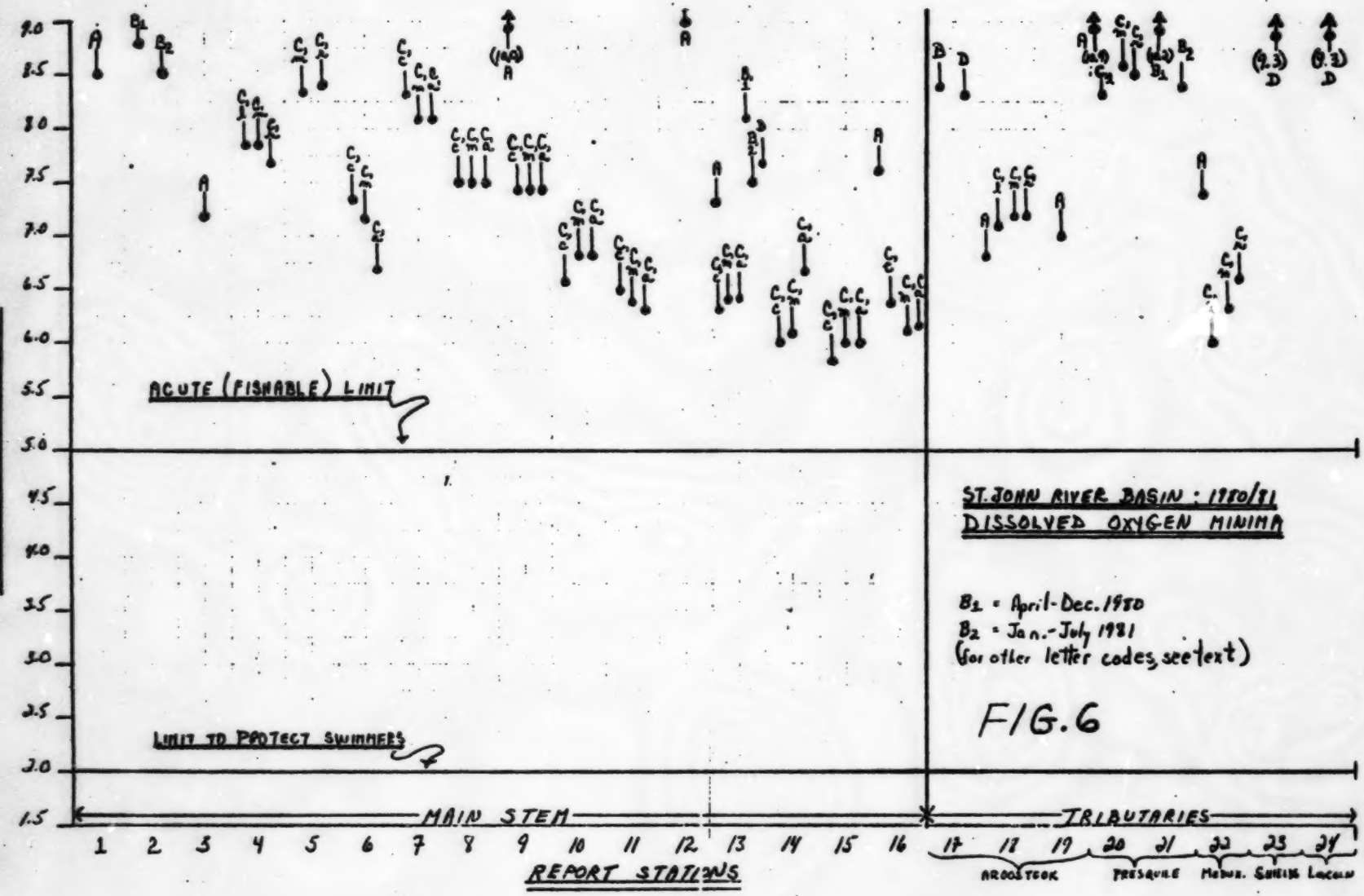


FIG. 5 ST. JOHN RIVER BASIN
% OXYGEN SATURATION: 1980/81

A: geometric mean
●: arithmetic mean
B1: April-Dec. '80
B2: Jan.-July '81
(see text for other letter codes)



REPORT STATIONS



ST. JOHN RIVER BASIN : 1980/81
DISSOLVED OXYGEN MINIMA

B_1 = April-Dec. 1980
B_2 = Jan.-July 1981
(for other letter codes, see text)

FIG. 6

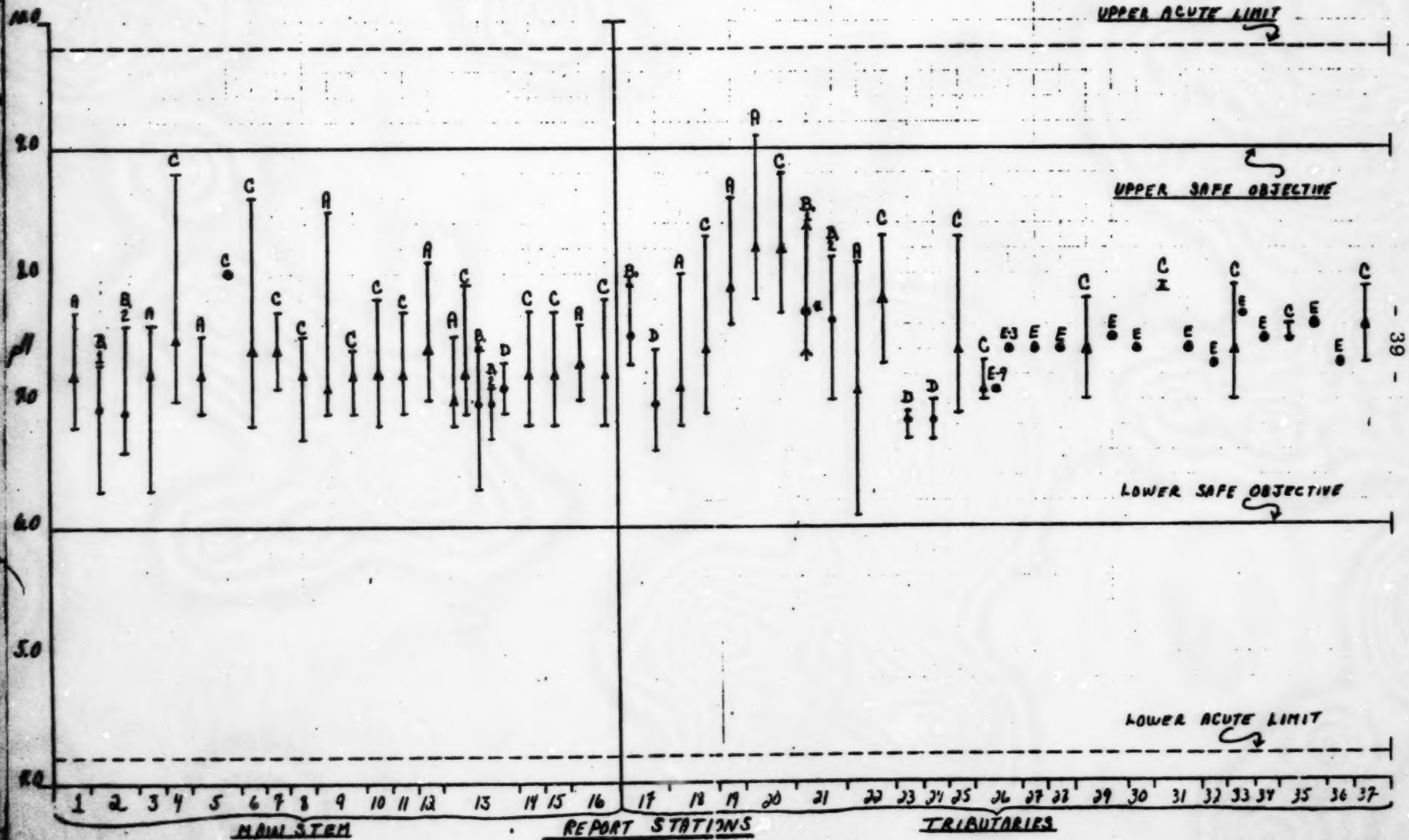
FIG. 7

ST. JOHN RIVER BASIN

pH : 1980/81

▲ : geometric mean
● : arithmetic mean
● : single value
↑ : "greater than"

B1 : April - Dec. '80
B2 : Jan. - July, '81
(for other letter codes, see text)



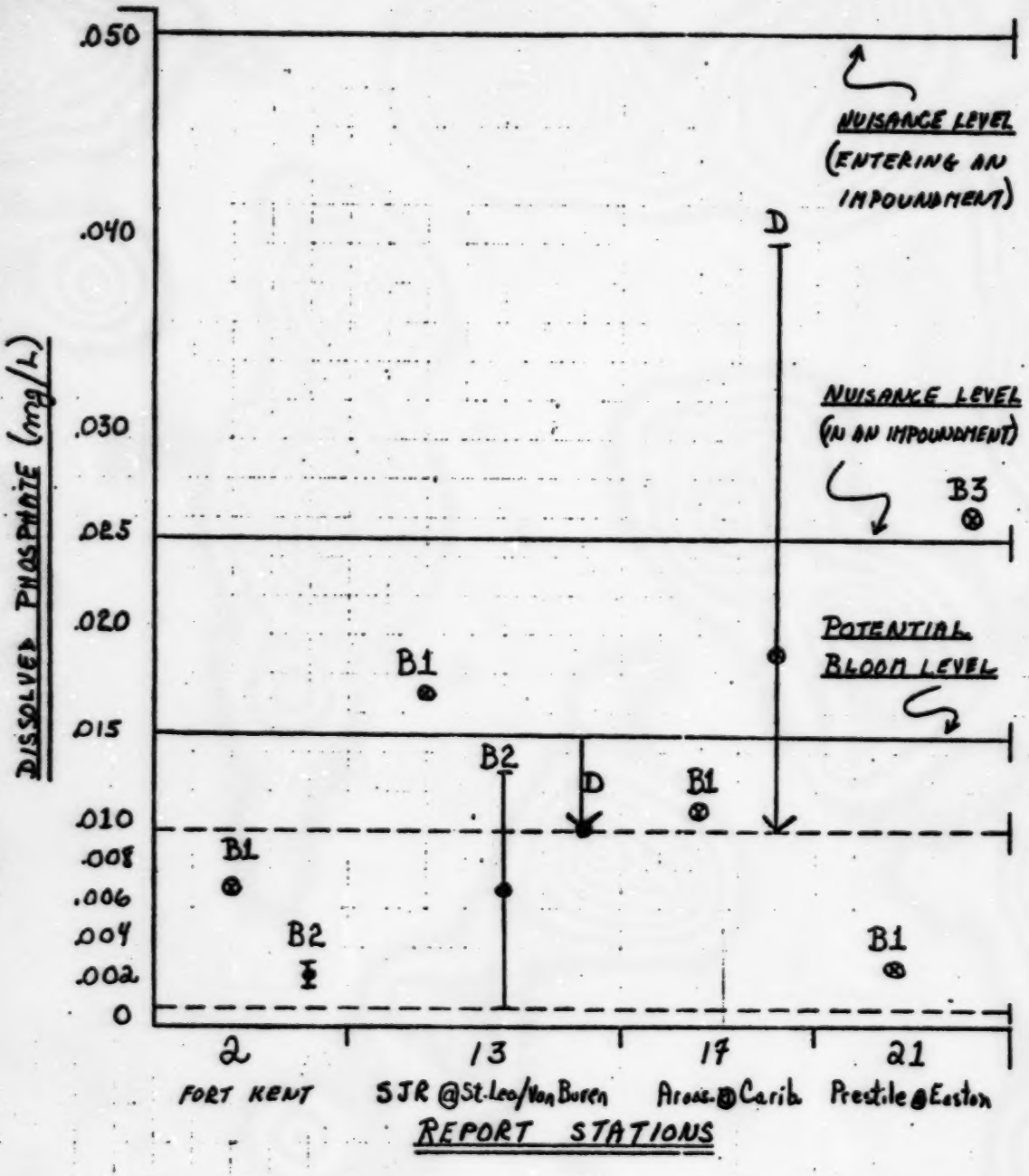


FIG. 8

SAINT JOHN RIVER BASIN

DISSOLVED PHOSPHATE

LEVELS: 1980/81

⊗ : Single value
● : arithmetic mean
↓ : "less than"
---: detection limit
B1: April, 1980
B2: April & July, '81
B3: July '81
(for other letter codes, see text)

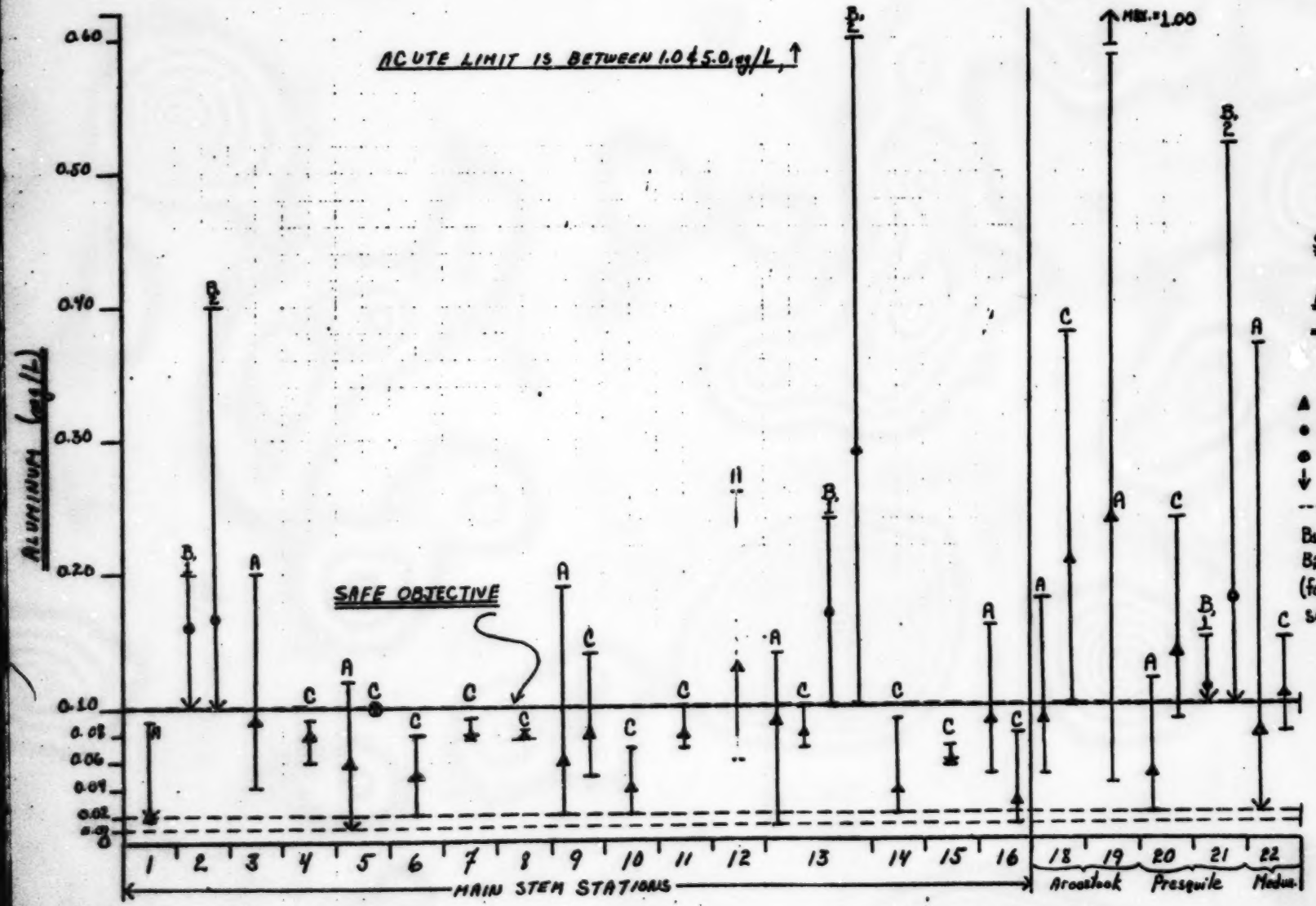


FIG. 9

ST. JOHN RIVER BASIN

ALUMINUM LEVELS 1980/81

▲ : geometric mean
● : arithmetic mean
● : single value
↓ : "less than"
--- : detection limit
B1 : Aug.-Nov. '80
B2 : Jan.-June '81
(for other letter codes, see text)

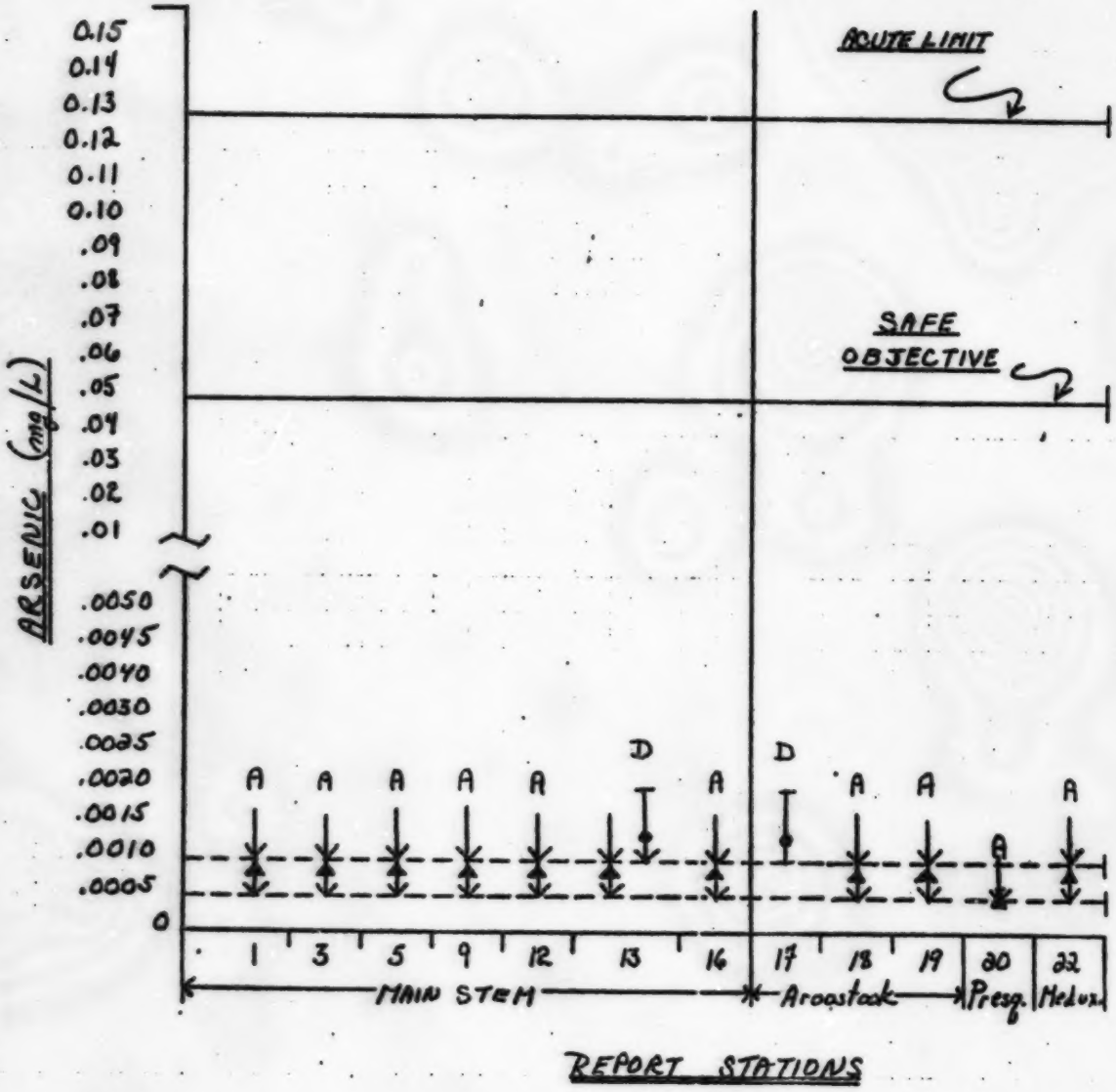


FIG. 10

ST. JOHN RIVER BASIN

ARSENIC LEVELS: 1970/71

▲ : geometric mean
● : arithmetic mean
↓ : "less than"
---: detection limit
(for letter codes, see text)

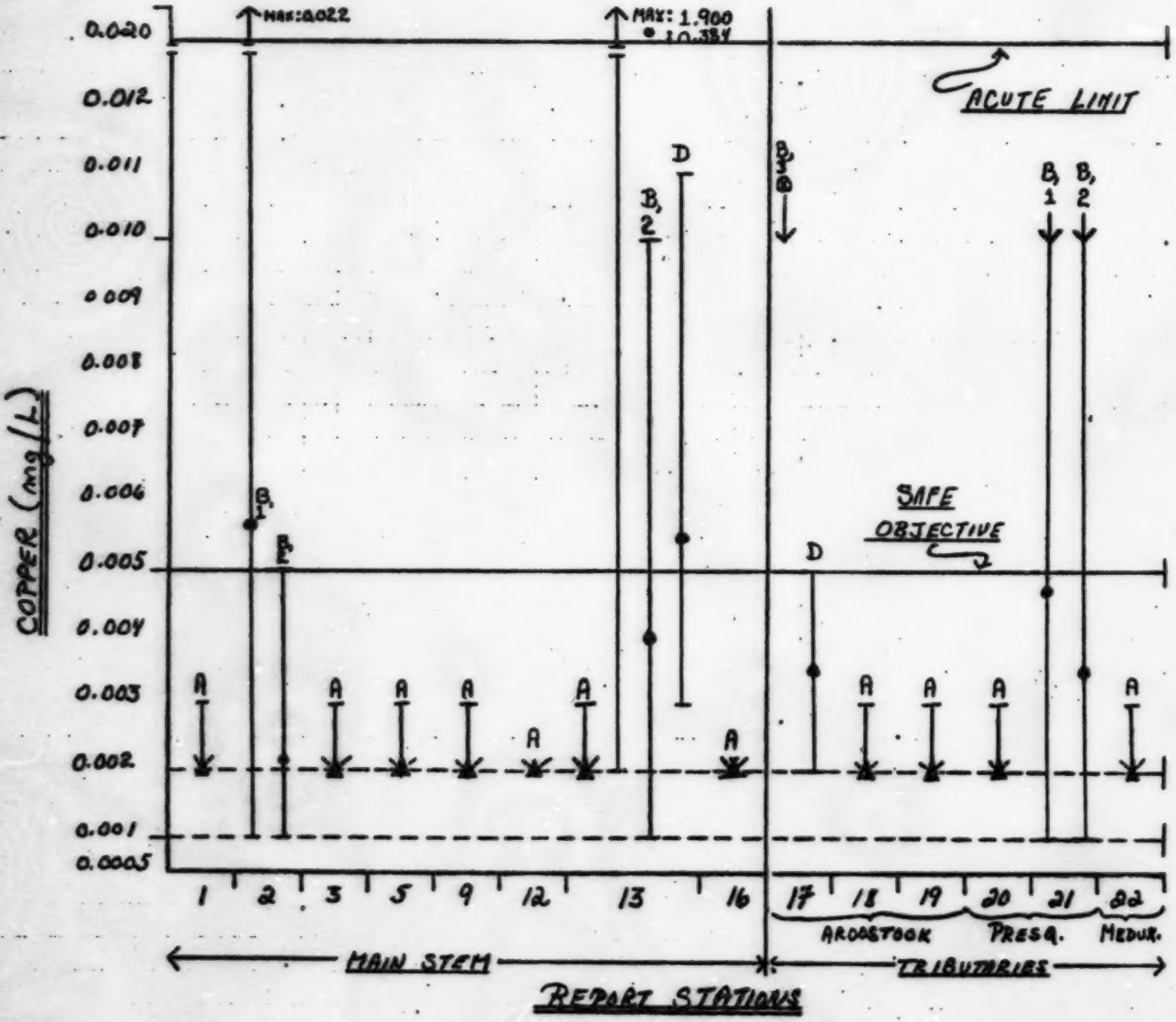


FIG. 11

ST. JOHN RIVER BASIN

COPPER LEVELS; 1980/81

▲ : geometric means
● : arithmetic means
↓ : "less than"
------: detection limit
e : single value
B1: April-Nov. '80
B2: Jan.-July '81
B3: April, 1980
(For other letter codes, see text)

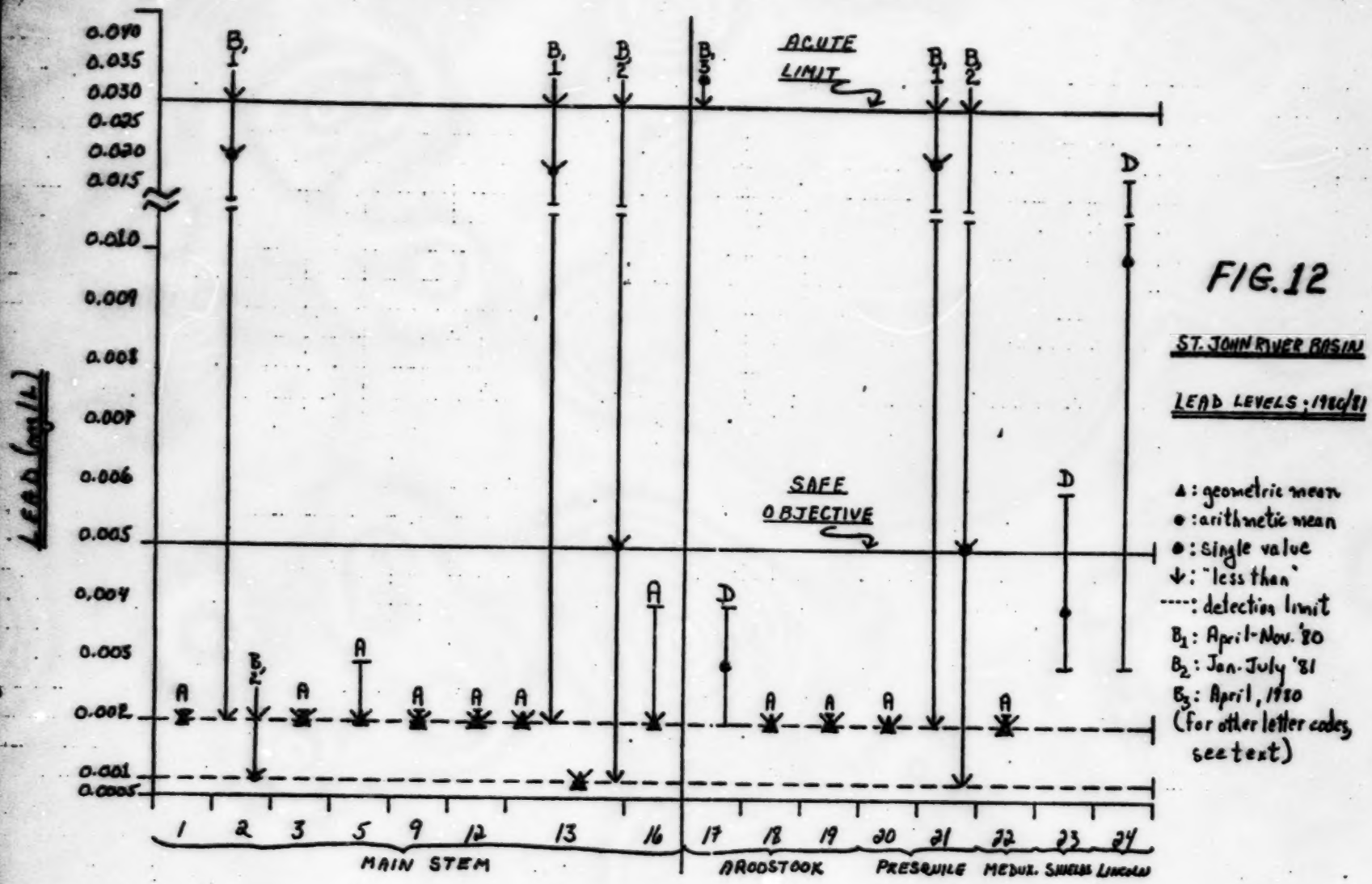


FIG. 12

ST. JOHN RIVER BASIN

LEAD LEVELS: 1980/81

▲: geometric mean
●: arithmetic mean
●: single value
↓: "less than"
----: detection limit
B_1: April-Nov. '80
B_2: Jan.-July '81
B_3: April, 1980
(For other letter codes, see text)

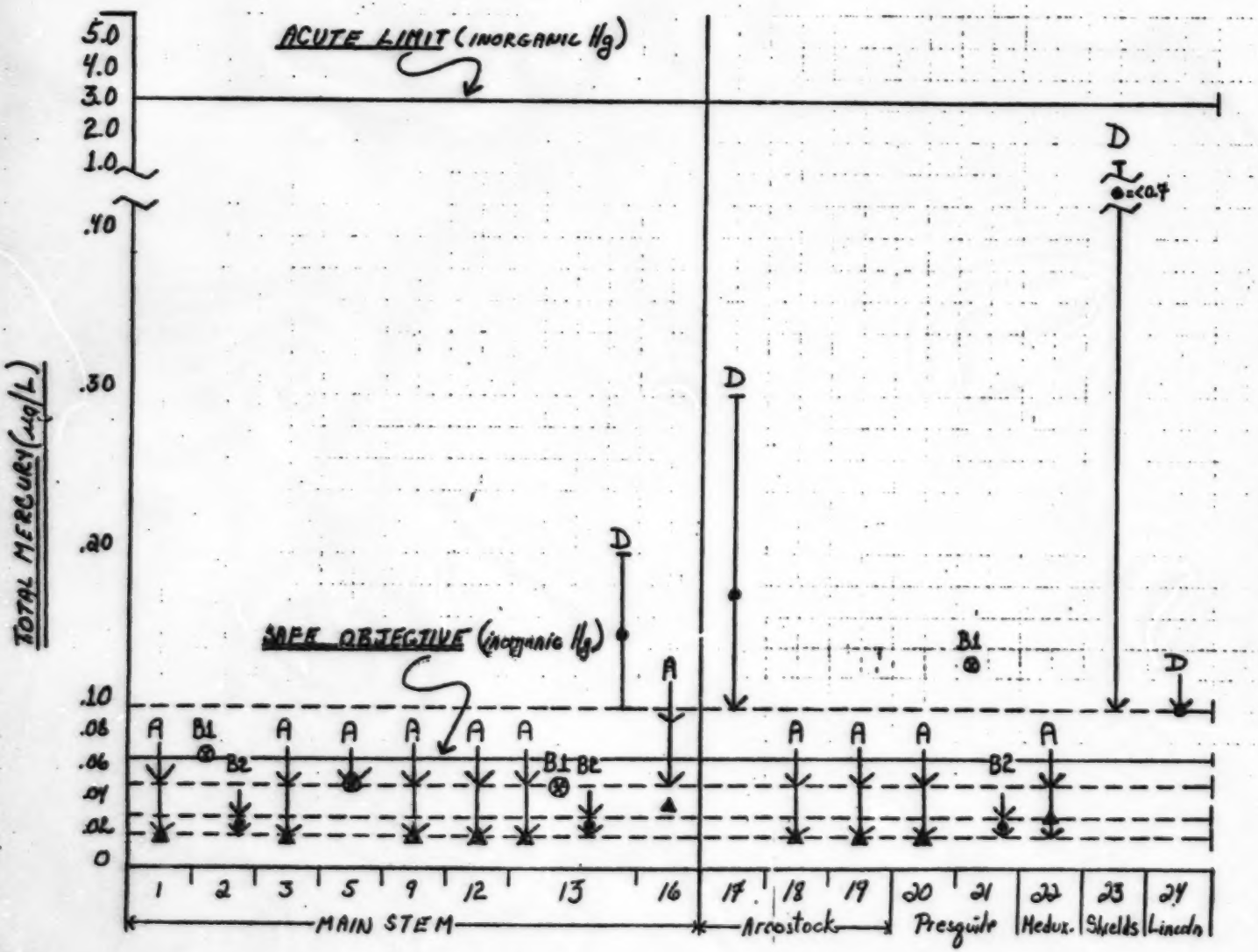


FIG. 13

ST. JOHN RIVER BASIN

MERCURY LEVELS: 1980/81

▲ : geometric mean
● : arithmetic mean
⊗ : single value
↓ : "less than"
---: detection limit
B1: July, 1980
B2: Feb.-June, 1981
(for other letter codes see text)

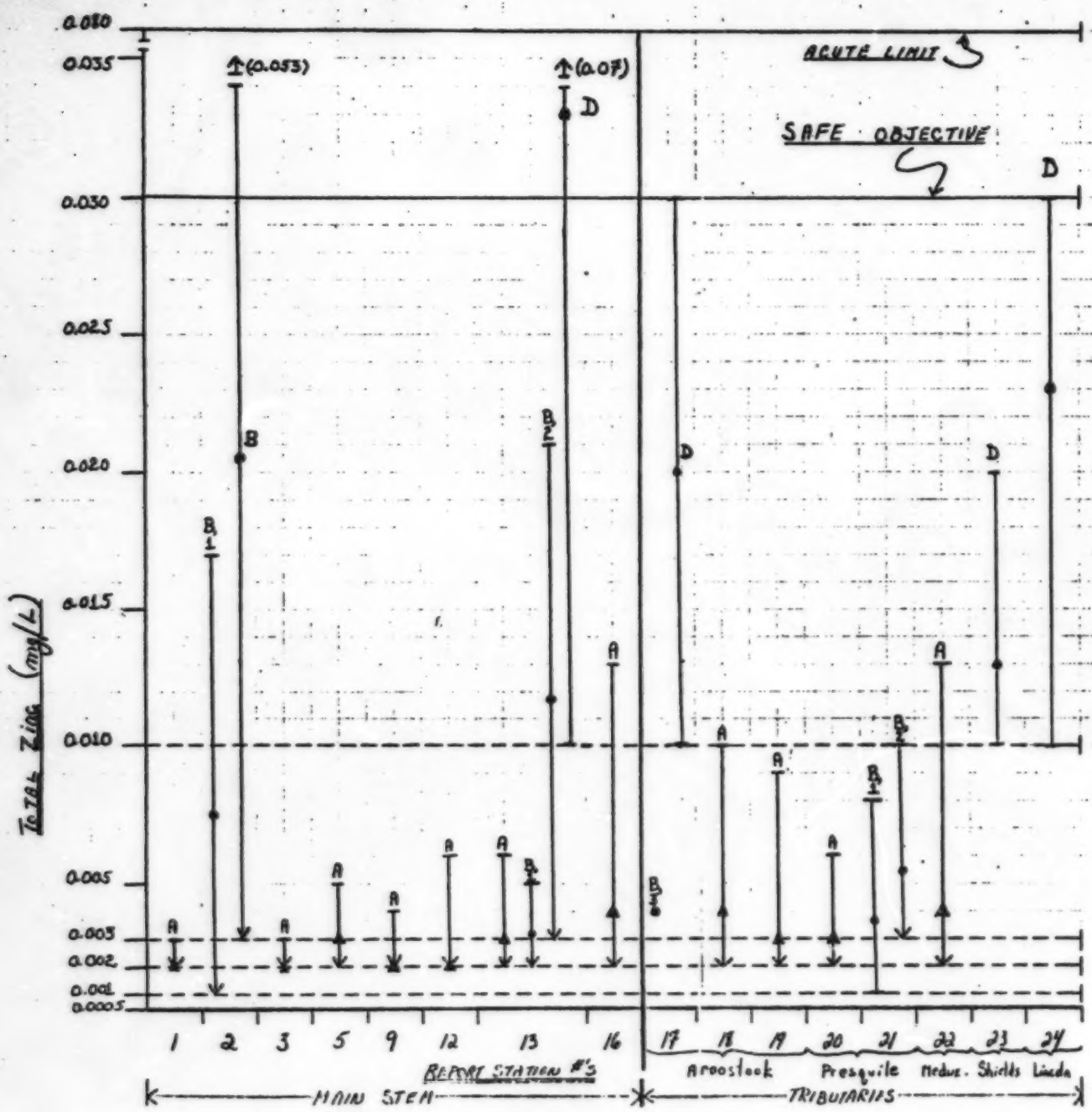


FIG. 14

ST JOHN RIVER BASIN

ZINC LEVELS,

1980/81

▲: geometric mean
●: arithmetic mean
↓: "less than"
B_1: April-Dec. '80
B_2: Jan.-July '81
B_3: April, 1980
(for other letter codes, see text)
---: detection limit

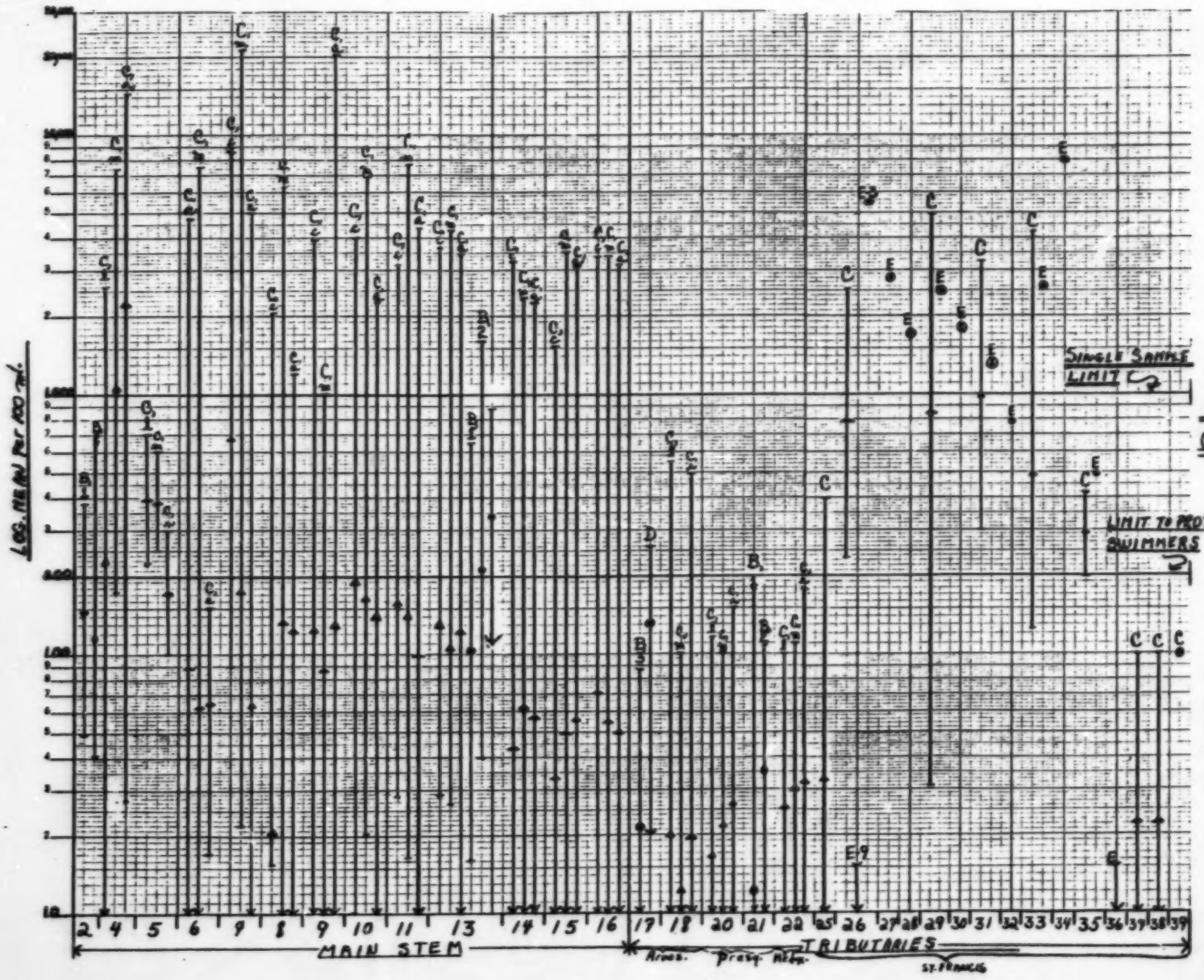

LOG. MEAN Per 100 ml.
SINGLE SAMPLE LIMIT
LIMIT TO PROTECT SWIMMERS
▲ : geometric mean
● : arithmetic mean
■ : single value
↓ : less than
B1: April-Dec. '80
B2: June-July '81
B3: April-June '80
(For other letter codes, see text)
2 4 5 6 7 8 9 10 11 13 14 15 16 17 18 20 21 22 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
MAIN STEM
TRIBUTARIES
Arroyo
Presq. Isla
St. Francis

FIG. 15

FECAL COLIFORMS: Mahi